REMARKS/ARGUMENTS

Drawing Objections:

The Examiner objected to Figure 1 of the drawings, suggesting that a legend such as "Prior Art" should be added to the figure. In response, Figure 1 has been amended to include the legend "Prior Art."

Further with regard to the drawings, the Examiner required that the reset reference voltage source of claims 1-40 be shown in the figures. The Applicant respectfully submits that the reset reference voltage source is shown in the figures as-filed. For example, in Fig. 2, the reset reference voltage source V_R is shown as being applied to the non-inverting input 49 of the amplifier A 33. Such is similarly shown in all of Figures 3-8.

To highlight the reference voltage source, Figures 3-8 have each been amended with the label for the reference voltage, V_R, now being circled in the conventional manner of a voltage source. No new matter is added with this amendment.

Objections to the Claims:

Claims 17, 25, and 29 were objected to for informalities.

In response, claim 17 has been amended to change the dependence of claim 17 from claim 15 to claim 16, as suggested by the Examiner; claim 25 has been amended to change "A" to "An" at the start of the claim, as suggested by the Examiner; and claim 29 has been amended to change the dependence of claim 29 from claim 27 to claim 28, as suggested by the Examiner.

Recitation of the Invention as-claimed:

The invention, as recited in claim 1, is directed to an image sensor. The image sensor includes a plurality of pixels which each have an output and a first circuit that produces a signal proportional to incident light intensity. This first circuit is connected to supply the proportional

signal to the pixel output, Each pixel also includes a select node connected to receive a select signal for selecting a given pixel from the plurality of pixels.

Each pixel also includes a reset transistor for resetting the pixel. The image sensor further includes an amplifier which has a first input for receiving outputs of the pixels. The amplifier also has an output that is coupled to the reset transistor of each pixel to provide a negative feedback signal to a selected pixel. A reset reference voltage source is connected to apply a reset reference voltage signal to the amplifier to provide a voltage reference for controlling reset of pixels.

Rejections of the Claims:

Claims 1-40 were rejected under 35. U.S.C. §102(e) as being anticipated by Kozlowski et al., U.S. Patent No. 6,532,040. The Examiner suggested that Kozlowski teaches a configuration of a plurality of pixels, with one pixel indicated by the dotted box in Fig. 3. The pixel of Kozlowski Fig. 3 is said to include an output, V_n, and to include a circuit that produces a signal proportional to incident light intensity, with the circuit connected to supply the proportional signal to the pixel output. The Examiner indicated that transistor M3 in Fig. 3 is a reset transistor for resetting the pixel. The Applicant agrees with this characterization of the Kozlowski pixel.

The Examiner goes on to suggest that Kozlowski also shows an amplifier (50) in Fig. 3, having a first input for receiving outputs, V_n of a pixel. The amplifier is also suggested by the Examiner to have an output that is coupled to the reset transistor of the pixel to provide a negative feedback signal to a selected pixel.

The Applicant respectfully submits that this is not the case. To aid in a discussion of the Kozlowski pixel amplifier configuration, Fig. 3 of Kozlowski and Fig. 2 of the instant application are reproduced below.

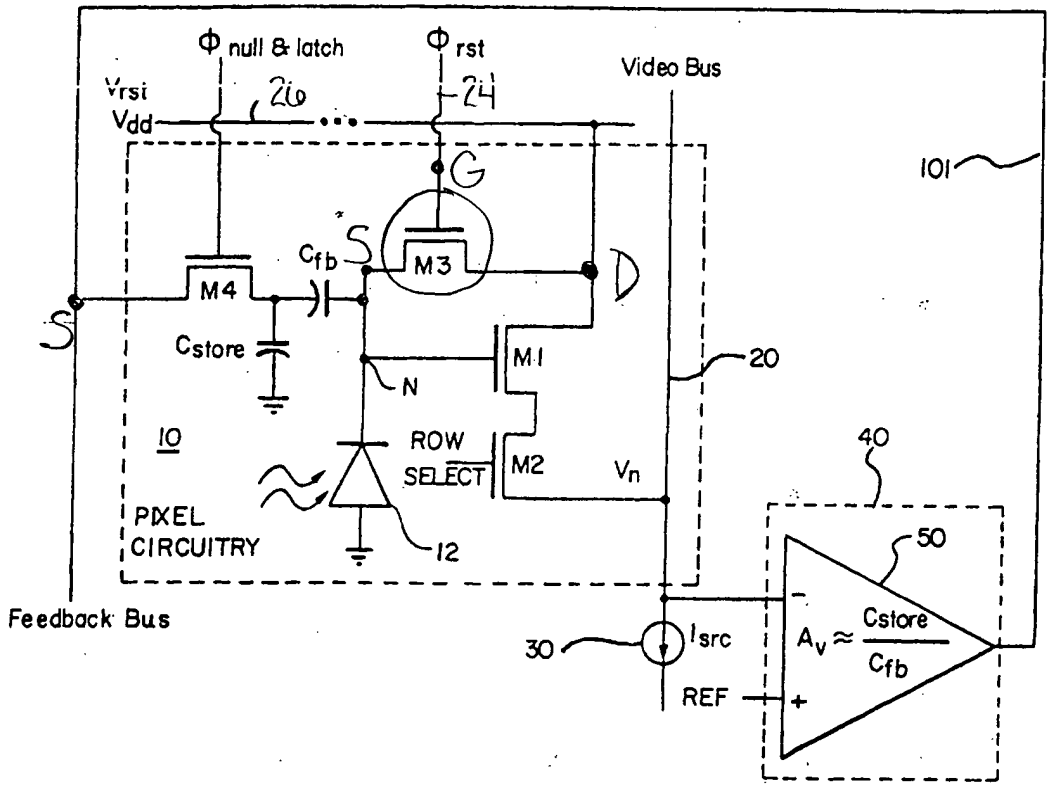

FIG. 3 KOZLOWSKI

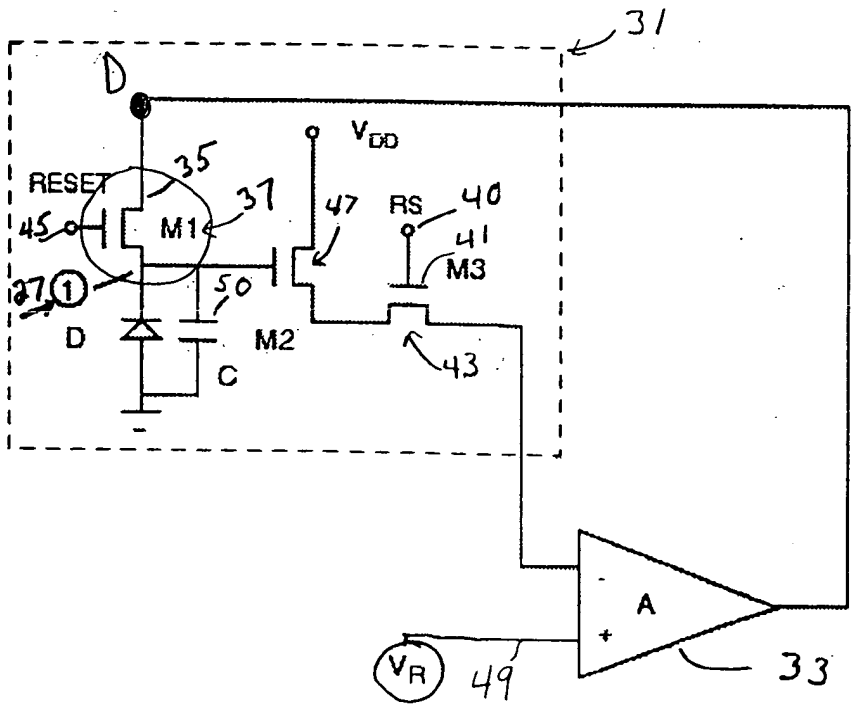

Fig. 2 INSTANT APPLICATION

In Kozlowski's pixel, the reset transistor, M3, has been circled. The source, S, gate, G, and drain, D, of the reset transistor M3 are labeled for reference, as given by Kozlowski Fig. 2. The gate G of the reset transistor M3 is connected to a reset clock Φ_{rst} - specifically, a row or column bus 24 (Fig. 2) connects the gate G of M3 to the reset clock (col. 7, lines 17-19). The drain of the reset transistor M3 is connected to a row reset supply voltage V_{rst} - specifically, a row bus 26 (Fig. 2) connects the drain D of M3 to a reset supply voltage (col. 7, lines 19-21). The source of the reset transistor M3 is connected to the cathode node N of the photodiode 12 and a capacitor C_{fb} of a sample-and-hold circuit.

None of the nodes of the reset transistor M3 are connected to the output of the amplifier 50. The output of the amplifier 50 is connected to the source S of transistor M4. With this connection, and with the corresponding required operation of the Kozlowski pixel, there is no coupling of the output of the amplifier to the reset transistor as required by the claims. Kozlowski specifically teaches against such, instead requiring that the output of the amplifier not be coupled to the reset transistor.

In operation, when a pixel is to be reset, the reset clock voltage Φ_{rst} is applied to the gate G of reset transistor M3, turning "on" the reset transistor, to enable connection of the reset voltage V_{rst} through the reset transistor to the cathode N of the photodiode 12. This clears the photo-induced charge from the photodiode (col. 8, lines 15-22). Then after the pixel is reset, the reset transistor M3 is turned "off", and the feedback amplifier 50 is engaged to "null out the noise" of the pixel value (col. 8, lines 61-62).

During this process, the null and latch clock voltage $\Phi_{null\&latch}$, is applied to turn "on" transistor M4, so that a feedback loop is closed, with the output of the amplifier applied to the source S of transistor M4. With transistor M4 turned "on" this output is applied through the transistor M4 to the storage capacitance, C_{store}. The stored capacitance is then coupled through the coupling capacitor C_{fb} to the integrating node N of the photodiode 12. This is the process described at col. 8, lines 23-42 referred to by the Examiner.

The reset transistor M3 is turned "off" during this process, and is therefore not in any way active or "on" during the process. The feedback loop applies a voltage to the integrating node N

of the photodiode through a transistor M4 that is entirely separate from the reset transistor M3 and M3 makes no part of the loop.

Thus, there is no connection and no coupling of the reset transistor M3 to the output of the amplifier 50. There is no connection from the amplifier output to the reset transistor, and further, when a feedback loop is engaged with the amplifier output, the reset transistor is turned "off" so that it is not active and could not be in any way coupled to the amplifier output.

In contrast, as shown in Fig. 2 of the instant application, in the pixel configuration provided by the invention and recited in claim 1, the output of the amplifier 33 is connected to the drain D (35) of the reset transistor M1 (37). In operation, when the reset transistor M1 is turned "on" by applying a corresponding voltage to the gate 45 of the reset transistor, the output of the amplifier is connected through the reset transistor to the node 1 of the photodiode D. The output of the amplifier is thus coupled to the reset transistor.

This pixel design and operation provided by the invention overcomes the limitation of the Kozlowski design in that it dramatically reduces the number of devices required to be included in a pixel. The Kozlowski design employs a conventional sample-and-hold circuit design, including the transistor M4 and capacitors C_{store} and C_{fb} to apply an offset voltage to the photodiode node N. The Applicant has discovered that this circuit can be eliminated and instead the output of an amplifier coupled to the reset transistor for directly applying an offset voltage to the node of the pixel photodiode during the reset process. The entire sample-and-hold circuit employed by Kozlowski is eliminated by the pixel design of the invention.

In addition, Kozlowski requires a second step, after pixel reset, to apply an offset voltage through his sample-and-hold circuit (col. 9, lines 46-62). In the invention, by coupling the amplifier output to the reset transistor, an offset voltage can be applied during the reset process itself, without the need for an additional step. The efficiency and speed of the pixel operation is therefore substantially improved by the pixel configuration of the invention.

The Applicant respectfully submits that with this discussion of the Kozlowski pixel configuration and operation, it is abundantly clear that the output of the Kozlowski amplifier is not coupled to the reset transistor of the Kozlowski pixel as required by the claims. The

Kozlowski amplifier output is coupled to a sample-and-hold circuit that is eliminated in the pixel design of the invention.

Independent claims 13 and 25 specifically require that an amplifier be connected to provide a negative feedback signal to the reset transistor. As is now clear, no feedback signal is provided to the reset transistor in Kozlowski's pixel. Like claim 1, claims 13 and 25 require a pixel configuration that eliminates the sample-and-hold circuit of Kozlowski, in which a feedback signal is provided to a sample-and-hold transistor M4.

The Examiner suggested that Kozlowski teaches a reset reference voltage source, REF, that is connected to apply a reset reference voltage signal to the amplifier to provide a voltage reference for controlling reset of pixels. Based on the discussion above, the Applicant submits that it is clear that such is not the case. The reference voltage source employed by Kozlowski is selected solely to normalize the offset signal of the pixel (col. 8, lines 40-41). Because Kozlowski's pixel configuration requires that pixel reset be carried out in a first, separate, previous step, prior to offset cancellation, the reference voltage does not play a role in control of pixel reset as required by the claims. In contrast, in the invention, the voltage reference is employed for controlling reset of pixels. Such cannot be accomplished by the Kozlowski pixel design.

Thus, the Applicant respectfully submits that Kozlowski fails to teach or even suggest the pixel design of the invention as recited in independent claims 1, 13, and 25.

Referring to claims 2, 14, and 26, the Applicant submits that while Kozlowski's amplifier includes a second input for receiving a reset reference voltage signal, Kozlowski's pixel design fails to meet the other requirements of the claims, as explained above.

Referring to claims 3, 15, and 27, the Examiner suggested that a first terminal of Kozlowski's reset transistor M3 is connected to receive a negative feedback signal to adjust a second terminal voltage of the transistor to a selected reset voltage. As explained above, this cannot be the case. Kozlowski's reset transistor M3 is not in any way connected to the feedback loop and cannot receive a negative feedback signal. There simply is no connection from the feedback loop to the reset transistor M3. Further, the reset transistor M3 is turned "off" when the

feedback loop is engaged, and thus could not adjust the voltage at its terminals; it is simply inactive during that time.

Referring to claims 4, 16, and 28, as well as claims 5, 17, and 29, requiring the reset reference voltage source signal selection, the Examiner referred to Kozlowski Col. 7, lines 1-34. This section describes the reset voltage, V_{rst} and power supply voltage, V_{dd}, applied to the drain of the reset transistor M3, but no discussion of the voltage REF is supplied at any point - Kozlowski is completely devoid of any teaching of specific selection of the voltage REF.

Referring to claims 6, 18, and 30, as well as claims 7, 19, and 31, requiring a configuration of a row select transistor and a source follower transistor, the Applicant agrees with the Examiner's characterization of Kozlowski's transistors M1 and M2 as such. But even so, Kozlowski's pixel design remains devoid of the required reset transistor coupling required by the claims.

Referring to the remaining claims, 8, 11, 20, 23, 32, 35, 9, 21, 33, 10, 12, 22, 24, 34, 36, 37, 38, 39, and 40, all of these claims depend from one of the independent claims 1, 13 or 25. In the interest of brevity, each of these claims will not be discussed in turn. All of these dependent claims include the limitations of the independent claims, as discussed above. Kozlowski fails to teach or even suggest the pixel configuration required by the independent claims, and no additional limitations, like those of the dependent claims, provide the missing requirements.

The Applicant therefore submits that the claims are in condition for allowance, which action is requested.

If the Examiner has any questions or would like to discuss the claims, he is encouraged to telephone the undersigned Agent directly at his convenience at the phone number given below.

Respectfully submitted,

Date: November 5, 2003

T.A. Lober Patent Services
45 Walden Street
Concord, MA 01742
Telephone 978.369.2181 / Facsimile 978.369.7101

Theresa A. Lober
Reg. No. 35,253
Agent for Applicant